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THESIS

A VENTURE CAPITAL MIXED MODEL FOR THE ACQUISITION OF DEFENSE SOFTWARE PRODUCTS

by

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June 2007

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13. ABSTRACT (maximum 200 words)

The major problem in the Department of Defense's acquisition of software systems is the growing number of cost and schedule overruns that result in failed software acquisitions. Cost and schedule overruns are the consequence of the software development models selected, inaccurate estimation of size, time, and cost, the instability of user requirements, and poor decision-making by acquisition managers. Commercial practices of requirements definition, vendor selection, development process, business practices, integration, development, and testing, maintenance, and rights in data were compared with equivalent Department of Defense practices. Commercial solutions are the implementation of open source standards and architectures, iterative software developments, increased collaboration among competing vendors, and the incorporation of software reuse. The Department of Defense's non-profit venture capital models utilize key practices, such as deal syndication and incremental funding, which are instrumental in managing risk and could be incorporated into how the DoD acquires software.

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ABSTRACT

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I would like to thank my thesis advisor, Prof. Rudy Darken, for providing me with an opportunity to explore the capabilities of venture capital within the Department of Defense framework. I would also like to thank my second reader, Prof. Ted Lewis, for providing exceptional insight into the current DoD Acquisition System. Both were instrumental in serving as a sounding board for many of the ideas presented in this thesis. Lastly, I'd like to thank my classmates, fellow Ensigns, and *The Crew* for making my time spent in Monterey as enjoyable as possible.

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EXECUTIVE SUMMARY

The Department of Defense and commercial industry are both motivated to acquire and develop the newest cutting-edge technologies. However, the funds necessary to develop innovative technologies are only appropriated under a certain set of expectations. Commercial industry is primarily concerned with taking a promising idea and molding it into a product line that will improve the company's bottom line, by increasing revenues or profit margins. Meanwhile, the DoD is focused solely on attaining a product with 100% user-defined functionality at the lowest cost possible and in a timely manner. Compared to Commercial industry's focus on achieving a significant level of user functionality, typically around 85%, and then increasing the functionality over a period of time, the DoD's requirement to meet 100% of the user-defined functionality in a timely manner is the reason there are so many software acquisition failures.

The Department of Defense has begun to explore alternative methods of procuring innovative technologies, most notably through the means of Venture Capital. In-Q-Tel, the Central Intelligence Agency's venture capital arm, was the DoD's first attempt at applying Venture Capital practices to improve the speed with which technologies are developed and deployed to the operational environment. In-Q-Tel invests in more risky projects/companies in comparison to the remainder of the government sector. In-Q-Tel funds companies involved in the research and development of cutting edge technology, which are inherently risky investments. However, with an increase in risk also comes the increase in reward. The rewards in this case are the speed with which commercially viable technologies can be identified, modified, and transitioned into the Department of Defense to enhance military capabilities and the added value of investing in commercial intellectual property early in the development lifecycle in comparison to when the technology is more mature and costly.

A brief look at recent and past investments by the government shows a tendency towards large capital appropriations for projects. The government seeks out solutions to existing military problems and deficiencies by attempting to develop broad solutions that can be scaled to multiple platforms and areas of interest, but must meet 100% of user-defined requirements. These projects are often cancelled years later upon the realization that the product currently in development does not fill the initial specifications or solves only part of the problem for which it was intended. One of the possible solutions to this problem of a one-stop solution is the use of open source community and standard architectures combined with the goal of software modularization. If the government were to fund smaller, more manageable software projects they would increase their chances for success, while also spending less money. Additionally, through an analysis of commercial practices a set of recommendations was developed to improve the overall probability of successfully acquiring software systems within the Department of Defense.

I. INTRODUCTION

A. BACKGROUND

The Department of Defense is neither acquiring nor developing the newest innovative technologies at the same pace as the private sector. The Department of Defense's Acquisition System hinders the speed with which technological advancements are made in the military. This lengthy acquisition process, a requisite for fielding new systems, is directly responsible for the slow transition of technology from the developmental laboratory to the operational environment as well as the lackluster rate of program success.

The Department of Defense Acquisition System is intended to be a risk management tool designed to reduce the risk of project failures. However, the reduction in the number of project failures comes at the expense to the amount of time required to field a new system. "One of the major challenges confronting DoD is to achieve rapid (within 6-18 months) exploitation of innovative, commercial information technology products in national security systems."[1] Compared to the private industry's short cycle times that can be measured in months, the Department of Defenses' technology turnover time is measured in years. On average, it requires approximately ten years to transition from research and development to deployment.[2] Additionally, when the system is eventually fielded it is often almost two generations behind current technologies available in the marketplace.[3]

Congress has recognized the restrictive nature of the acquisition process and the inherent problems that result from its required usage. According to the House Report associated with the Defense Appropriations Act of 2003, "the Navy's research and acquisition community historically has had great difficulty in transitioning innovative

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[1] "Information and Command and Control." Aerospace America (December 2004).

[2] Paul Mann, "Profit Incentives Urged for Defense R&D." Aviation Week & Space Technology (March 2000).

[3] Ibid.

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technologies for government research organizations and the commercial marketplace to active deployment and procurement programs. Due to the constraints of internal planning and budgeting processes, and the stifling legacy of 'programs of record', new Navy systems are often fielded with a high degree of obsolescence..."[4] Therefore, if the Department of Defense is expected to keep up with speed of innovation evident in the commercial marketplace, it must begin to investigate alterations to its current Acquisition System.

The Department of Defense's acquisition of software systems over the last few decades has been a major cause for concern. Software system acquisitions typically fail as a result of one or more of the following factors: the inherent complexity of the software system, poor estimation of size, time, and cost, unstable user requirements, and poor decision-making by acquisition managers. "The development, acquisition, and delivery of software are essential to the Navy's ability to successfully conduct its business and perform its missions."[5]

Many of today's cutting-edge weapon systems are increasingly dependent upon software. According to Lisa Pracchia, a member of Naval Air System's Command Software Resource Center, "software enables a myriad of complex capabilities from massive data fusion across geographically disparate large-scale sensor systems, to decisional systems that automatically select the most appropriate weapon and platform to attack a given target."[6] Examples of software-intensive systems include flight control systems, fire control systems, C4I systems, and autonomous mission planning systems; all of which would not be mission-effective without software. Within the past few years, software has even made great strides into improving the battlefield performance of infantry soldiers in various combat environments. These technological advancements are accompanied by an increase in software's fraction of the weapons system's life cycle cost. This increase in software costs is further magnified by optimistic cost estimates and delays in development and integration phase schedules.

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[4] Department of Defense Appropriation Act, 2003, House Report 107-532 U.S.C. (2003).

[5] "Panel: Defense Software Problems Put Info Dominance 'At Risk'." Inside the Navy (July 2006).

[6] Lisa Pracchia, "Improving the DoD Software Acquisition Processes." CrossTalk (2004).

Despite the Navy's dependence upon reliable software systems, over the last decade an increasing number of software development initiatives have experienced major cost and schedule overruns. According to the Undersecretary of Defense, Jacques S. Gansler, systems currently in development are increasingly dependent upon software and it is from software issues that spawn many of the problems in cost and schedule impact arise.[7] A recent naval study conducted by the Naval Research Advisory Committee concluded that the Department of Defense must reconsider their current acquisition process for fielding new software systems. "The Navy has problems specifying, developing, acquiring, testing, maintaining, and researching software systems...The department also lacks experienced software acquisition professionals...Attempts to address testing, security, and interoperability are often too late... and the Navy is not investing enough money in software research."[8] The software that must be integrated with newly developed and pre-existing weapon systems is driving the cost of building the Navy's future fleet of warships even higher.

Successful software acquisitions, as recognized by the Department of Defense, meet two specific criteria – 100% requirement compliance and the development of the software technology in a timely manner. The DoD recognizes a window of 5-8 years as an acceptable timeframe for development. Compared with commercial industry's timeframe for development of 6-18 months, it is no surprise the DoD is lagging with respect to the development of innovative technologies. The commercial industry is able to measure their technology development timeline on a scale of months rather than years, as a result of meeting core user requirements through the incorporation of commercial-off-the-shelf (COTS) products and software reuse. Therefore, the commercial industry's measure of success is meeting an acceptable level, generally 85%, of user requirements within 6-18 months.

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[7] Paul Mann, "Profit Incentives Urged for Defense R&D." <u>Aviation Week & Space Technology</u> (March 2000).

[8] "Panel: Defense Software Problems Put Info Dominance 'At Risk'." <u>Inside the Navy</u> (July 2006).

B. SCOPE OF THESIS

This thesis provides an in-depth assessment on the current structure of Naval software system acquisition and whether or not it could benefit from the implementation of venture capital investment and management practices coupled with commercial software practices. Chapter II discusses the different software development models utilized in Department of Defense software acquisitions, software cost management, and the most common reasons for software acquisition failures in the DoD. Commercial practices for acquiring software are contrasted with the Department of Defense's current practices in Chapter III. Chapter IV explores the Department of Defense's implementation of non-profit Venture Capital firms. Conclusions and recommendations are discussed in Chapter V.

C. THESIS STATEMENT

The adoption of venture capital practices, such as deal syndication and incremental funding, coupled with the commercial software practices of open source standards and architectures, iterative software developments, and increased collaboration amongst competing vendors, will increase the number of successful software acquisitions.

II. WHY DEPARTMENT OF DEFENSE SOFTWARE ACQUISITIONS FAIL

Within the Department of Defense, successful software projects are the exception. Most experience significant cost and schedule overruns leading them to exceed their budget and resulting in program termination. These acquisitions are capial-intensive and known for being significantly high-risk projects. The Standish Group's annual Chaos Report tracks Information Technology successes and failures (See Figure 1). According to the figure below, it is evident that as the level of funding increases the probability of success decreases rapidly.

Project Success
Smaller initiatives fare better at reaching goals than larger projects do.

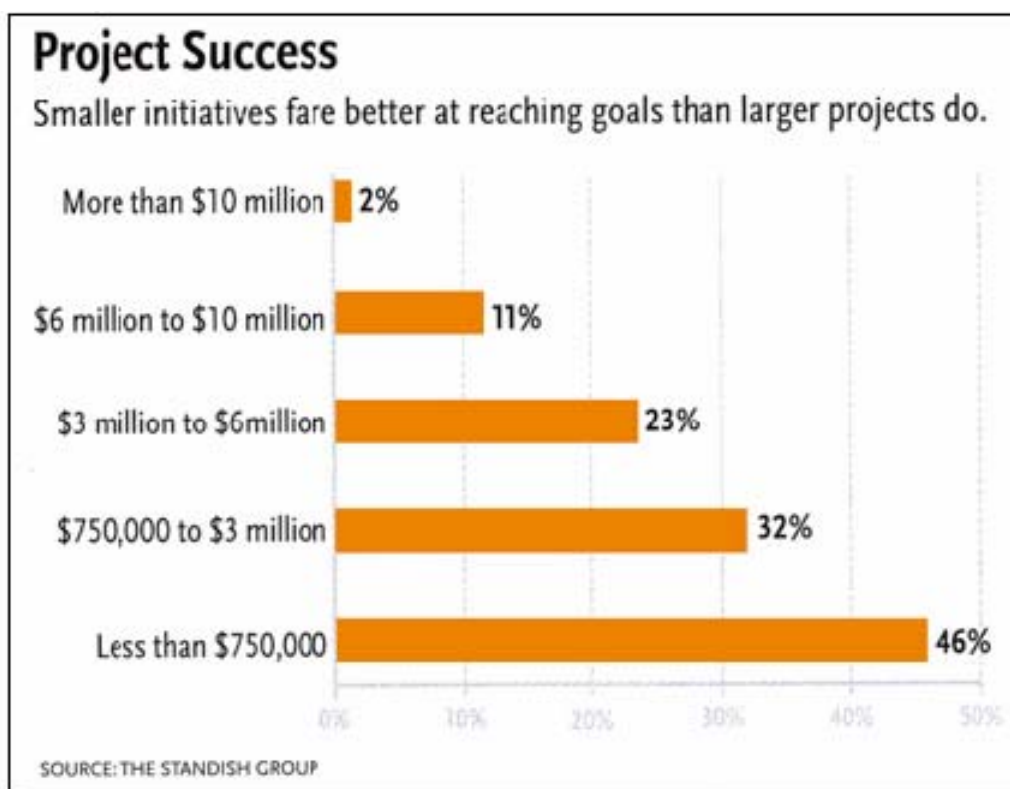| Project Size	Success
More than $10 million	2%
$6 million to $10 million	11%
$3 million to $6million	23%
$750,000 to $3 million	32%
Less than $750,000	46%

SOURCE: THE STANDISH GROUP

Figure 1.　　Software Project Success [From: Schwartz]

In addition to significant capital appropriations, DoD software failure typically results from the software development model selected, unstable user requirements, and the program manager's software cost management practices.

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A.   SOFTWARE DEVELOPMENT MODELS

The most common software development models used in Department of Defense Software Acquisitions are the Waterfall and Spiral models. Each of these models is assessed on their ability to meet 100% user-defined requirements and the time required to deploy the technology.

1.   Waterfall Model

The Waterfall model is a highly structured, documentation-intensive, sequential model, which replaced the initial "code and fix" method of software development and is now considered to be the traditional approach to software development. This model provides a well-documented system for increasing both the success of large software projects and the accuracy of cost and schedule estimates. However, its sequential nature prevents feedback between phases. Moreover, due to the fact that a working product is not available until late into software development, mistakes or errors in earlier phases often propagate through later phases. The Waterfall model is often successfully applied to low risk projects where software requirements are well understood and are not expected to change throughout the project life cycle.[9]

The Department of Defense favors the Waterfall model due to its rigid structure and the amount of documentation it requires. These characteristics are perceived by the DoD to be essential in minimizing program risk. However, user-defined requirements are constantly changing in DoD software projects and therefore present a significant challenge to software developments utilizing this model. Since there is no method of addressing changes in user requirements throughout the software development process, the resulting product often does not meet the required level of 100% compliance. Additionally, a reduction in funding or program termination would leave little to be

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[9] "Guidelines for Successful Acquisition and Management of Software-Intensive Systems: Weapon Systems, Command and Control Systems, and Management Information Systems." Department of the Air Force: Software Technology Support Center (February 2003).

salvaged for future work, since the Waterfall model does not produce a working product until late in the development process. Therefore, although this model is perceived to reduce risk, in reality it actually increases risk for the Department of Defense.

2. Spiral Model

The Spiral model's main purpose is to reduce risk by identifying high-risk problems as they arise throughout the software life cycle. With each iteration of the model, objectives, alternatives, and constraints are identified, risk analysis is conducted, the software product is further developed, and plans are reviewed for the next cycle. The model is adept at incorporating new technologies, reducing risk, and developing a system that is far more responsive to user needs. However, this model usually increases development cost and is more difficult to manage than others. The Spiral model should be considered for projects with high risk and an increased likelihood of evolving requirements.[10]

The Department of Defense utilizes the Spiral model in its software developments since it provides more than adequate analysis of risk throughout the development process. This is accomplished through the significant amount of documentation that is generated with each iteration of the model. The resources required to persistently document the software development, analyze risks, and identify objectives and alternatives directly increase the costs of developing the software. Additionally, completing these tasks consumes a substantial portion of valuable development time, which could result in compounded schedule overruns that delay the system's time to deployment. Therefore, the Spiral model is not the ideal software development model to acquire software for the Department of Defense.

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[10] "Guidelines for Successful Acquisition and Management of Software-Intensive Systems: Weapon Systems, Command and Control Systems, and Management Information Systems." Department of the Air Force: Software Technology Support Center (February 2003).

B.   UNSTABLE USER REQUIREMENTS

The notion that requirements will change over time is well understood, but the practice of developing software systems with a model and architecture that support changing requirements remains ignored. Another factor that must be considered is how and when to incorporate new or modified requirements. If requirements are revised to frequently, cost and schedule overruns are likely since the software development is not able to gain much traction. Therefore, it is imperative to control the modification of requirements to minimize requirements creep and increase the chances of developing a software system that meets the user's required level of functionality. One way to ensure requirement compliance and increase the likelihood of meeting required functionality is to solicit feedback from the software system's user. User involvement is critical to determine whether perceived user needs have been correctly translated into software functionality.

C.   PROGRAM MANAGER SOFTWARE COST MANAGEMENT

Project managers are tasked with controlling cost fluctuations, while simultaneously achieving performance milestones and scheduled deliverables. In addition, the budget from which they receive funding is based upon their own estimates of software development. With respect to software development projects, the majority of cost pertains to staffing, which is a numerical figure determined by the size of the software system being developed. In order to accurately estimate this cost, one must have knowledge of the number of people needed and the amount of time necessary to complete their assigned task. The accuracy of these estimates is often over-estimated as they are simply the product of guesswork formulated from an analysis of an analogous system's historical data. Program manager estimation of cost, time, and size and method of determining software development cost contribute to the failure of DoD software acquisitions.

1. Inadequate Estimation of Cost, Time, and Size

An inability to adequately estimate cost, time, and size is the fundamental reason for software-intensive development cost and schedule overruns. The effects of these optimistic estimates are compounded in software acquisitions since predicting size and complexity of software developments is challenging when there is no analogous system to gauge the accuracy of a program manager's estimates.

The increased optimism of contractor and program manager estimates stem from Congress' spending and budgeting scrutiny. Since best-case estimates increase a program's chances of being funded or approved, there is little motivation for acquisition professionals to provide more pessimistic estimates that account for deviations in the software development process and incorporate worst-case scenarios. Additionally, contractors are motivated to egregiously underestimate a software program's cost since the DoD Acquisition System generally awards funding to the contractor with the lowest cost and schedule estimates, given they meet all other requirements. Once awarded the contract, it is not uncommon for there to be increases in cost and schedule throughout the program's lifecycle that more accurately reflect the program's true cost and delivery timeline.

These optimistic estimates often do not account for the cost of a chaotic software development. Programs tend to get in trouble in small, progressively compounding increments. When the software system is expected to experience cost and/or schedule overruns due to inadequate estimation, it is not uncommon for the developer to reduce the number of requirements to be fulfilled and the amount of testing to be conducted. However, the elimination of user requirements and reduction in the number of tests to be run significantly impact the final product. In these cases, the software system falls short of meeting the user's required level of functionality and/or is riddled with defects, which limit its deployability to the operational field. Therefore, the inadequate estimation of time, size, and cost results in unrealistic delivery schedules and insufficient program funding.

2. Method for Determining Software Development Cost

The key measurement for determining software development cost is the size of the software system being developed. The predominant method for estimating software size is through source lines of code (SLOC). The SLOC approach is most commonly practiced despite three significant drawbacks. First, the lack of a universal standard for what determines a source line of code makes it difficult to compare multiple developer estimates. Second, since the developer is compensated based on a flat rate per source line of code he has an incentive to increase the number of lines of code required for the software, directly increasing compensation. This effectively removes efficient programming practices as the developer is motivated by compensation and not efficiency. Lastly, in most software development programs, multiple programming languages are used and estimates of cross-language lines of code are inconsistent, exponentially increasing the number of potential pitfalls for developing software.

Lastly, initial releases of the software development often perform inadequately and the cost of modification is prohibitive. If problems are not caught in a timely manner, the cost of making and correcting defects often soars beyond acceptable levels. Unfortunately, this results from scheduled milestones that force the developer to choose between delivering the product as scheduled with known deficiencies or delaying its release and facing the consequences of schedule delays. In addition, there always exists the possibility of unknown hardware deficiencies that may require costly software modifications.

Schedule overruns, no matter how small and insignificant they may appear, almost always lead to an increase in costs. As a result of the numerous challenges that result from the poor estimation of software systems and inadequate software development models, it is imperative that the Department of Defense takes steps to improve software acquisitions.

III.   SOFTWARE ACQUISITION: A COMPARISON OF DEPARTMENT OF DEFENSE AND COMMERCIAL PRACTICES

A.   BACKGROUND

The Department of Defense's software acquisition practices can be compared with common commercial practices of acquiring software. The following comparison is conducted on the basis of two key issues -- (1) specific industry methods and (2) the integration of commercial-off-the-shelf (COTS) products. Only the specific industry methods used in acquiring software systems are similar to those currently developed by the Department of Defense and the practices of incorporating COTS products into complex software systems are compared. An analysis of COTS products is important since research and development has been increasingly coming from privately funded projects as opposed to the traditional sources – government and academic laboratories. Therefore, the ability to incorporate commercial tools has become more valuable and the ability to leverage private sector projects means faster implementation of technology – rather than awaiting custom-designed tools.[11]   An in-depth analysis of these issues exposes both the benefits and risks associated with implementing certain commercial practices within Department of Defense software acquisition programs.

B.   COMMERCIAL INDUSTRY VS. DEPARTMENT OF DEFENSE SOFTWARE SYSTEMS[12]

The software systems acquired and maintained by both the commercial industry and the Department of Defense can be classified into three major groups – Real-Time Embedded Control systems, Information systems, and Command, Control, Communications, Computing, and Intelligence (C4I) systems. Characteristics of Real-

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[11] Gary Arlen, "For Tech's Sake: Can In-Q-Tel's investment model translate into other agencies?" Washington Technology (22 April 2004). 20 May 2007 http://www.washingtontechnology.com.

[12] Michael E. DeRiso and Jack R. Ferguson, "Software Acquisition: A Comparison of DoD and Commercial Practices." (1994).

Time Embedded Control systems include interrupt-driven processes, large numerical processing requirements, small databases, tight real-time constraints, and well-defined, diverse user interfaces. In addition, their requirements and design are driven primarily by performance constraints. Examples of these software systems include aircraft control systems and fire control systems. Information systems are transaction based, consisting of moderate numerical processing requirements and large databases. In addition, these systems have flexible time constraints and user interfaces. The requirements and design of Information systems are driven by their user interface. Examples include accounting, personnel, and supply management systems. Lastly, C4I systems require large numerical processing requirements and large databases. They also have near-real time requirements and user interfaces that vary in complexity and flexibility. Both performance and user interface drive the requirements and design of these types of software systems. An example of a C4I system is a missile warning and control system. Software systems that fall within the first two categories are commonly developed by both the Department of Defense and commercial industry. However, the third type of software system, C4I systems, applies mainly to the Department of Defense. In addition to these three major types of software systems, commercial industry also develops general-purpose software such as operating systems and task oriented solutions to enhance office productivity.

The following sections and tables contrast common commercial practices with those typically used in Department of Defense software programs, focusing on the areas of requirements definition, vendor selection, development process, business practices, integration, testing, delivery, maintenance, and rights in data.

1.   Requirements Definition

Commercial industry is able to better define requirements due to the nature of the relationship between the buyer and the user. In commercial industry the buyer and user are typically the same, while in DoD acquisitions they are rarely the same. In the DoD, the source of the problem is the program office, which does a poor job of translating mission needs into product requirements.

During the process of defining requirements, commercial industry has adopted the practice of researching existing product solutions and incorporating their technology or increasing their functionality to meet their specific needs. Thus, it is evident that commercial industry is more willing than the Department of Defense to trade functionality for the possibility to decrease cost and schedule. This increased flexibility enables commercial industry to develop software systems with the focus of delivering a functional product ahead of schedule and then evolving it to include later requirements. In addition, one of the best commercial practices is the formation of an Integrated Product Development (IPD) team, which consists of all parties to be involved throughout the program's life cycle. With this team in place, all parties are able to effectively communicate any rising concerns throughout all phases of software development.

Also, it is common practice for commercial software companies to think in terms of product lines that fit into standard architectures. This practice enables them to achieve the goal of creating software products that can easily be tailored to meet different user requirements.

An analogous practice to thinking in terms of product lines for the Department of Defense would be to focus on building tailored software modules that can be plugged into a standard open architecture. Additionally, the Department of Defense could also improve by requiring acquisition professionals to set up test acquisitions, which would enable them to explore various functionality/cost tradeoffs.[13] Through the implementation of Advanced Concept/Technology Demonstrations (ACTD), the Department of Defense has begun to explore the advantages and disadvantages of systems developed by competing contractors.

Lastly, the adoption of a team approach could potentially increase the government's visibility into the supplier's present, past, and future programs thereby decreasing program risk. Most importantly, the addition of the software system's end

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[13] Michael E. DeRiso and Jack R. Ferguson, "Software Acquisition: A Comparison of DoD and Commercial Practices." (1994).

users to the IPD team is vital to the success of any software system acquisition. Table 1 contrasts commercial industry practice and the Department of Defense practice pertaining to requirements definition.

Requirements Definition	
Commercial Practice	DoD Practice
Requirements based on strategic plan and market analysis.	Requirements based on requesting command's Mission Need Statement.
Requirements based on life-cycle resource constraints.	Requirements based on annual budget resource constraints.
Detailed requirements generated by team consisting of users, subject matter experts, and system engineers.	Detailed requirements generated through collaboration of the buyer with the user. Team consists of subject matter experts and acquisition personnel.
Functional specification is modified by knowledge of existing product solutions.	Functional specification is created with little to no regard for existing product solutions.
Vendors involved early in study, analysis, prototyping. Emphasis on reuse and evolution of existing systems.	Contract may include prototypes, but contractor involvement in pre-award discussions is discouraged.
Additional requirements tradeoff decisions concerning complexity and schedule for reduced time to field.	Limited flexibility to trade off requirements creep versus complexity and schedule.
Summary:	
Commercial practices are more flexible and open between users and suppliers. In the commercial sector, there is more willingness to adjust requirements based on availability of products and thus to field a system earlier and evolve it to include more capability.	

Table 1.   Requirements Definition. [From: DeRiso and Ferguson]

2. Vendor Selection

The differences in vendor selection between commercial industry and Department of Defense are significant. From Table 2, it is evident that the commercial industry has an entirely different relationship with suppliers. These differences include which vendors

each solicit and how each vendor is selected. For instance, in commercial industry vendors are encouraged to form teams with other qualified vendors to create an environment that fosters rapid technology development through tradeoffs in cost and schedule. In addition, the formation of teams filled with qualified vendors all working cohesively towards the development of the software system provides the foundation for future collaboration on new and innovative software ventures.

Commercial industry's objective in software development is to obtain the best possible product at a reasonable price and as soon as possible. When comparing this to the Department of Defense's objective of obtaining a product with 100% user-requirement compliance at the lowest possible price, it is not surprising that a significant number of software acquisition programs often experience cost and schedule increases, ultimately leading to program termination. However, their ability to negotiate with suppliers and to engage in long-term contractual relationships covering both the development and maintenance phases, similar to commercial industry, is not permitted under current regulations. In addition, the Department of Defense's requirements to maintain public trust and to be rigorously fair constrain its ability to modify existing vendor selection techniques.[14]

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[14] Michael E. DeRiso and Jack R. Ferguson, "Software Acquisition: A Comparison of DoD and Commercial Practices." (1994).

Vendor Selection	
Commercial Practice	DoD Practice
Solicit multiple qualified vendors. Encourage teaming with a view to attaining a relationship that covers the entire life cycle and fosters tradeoffs in cost and schedule.	Solicit all possible vendors. Vendor proposals must meet 100% of requirements. Teaming seldom encouraged since development and maintenance are usually separate entities.
Compare vendor history and experience. Maintain long-term relationships for future business.	Can compare previous performance, but long-term relationships generally discouraged.
The organization that will be responsible for a system over its full life cycle is heavily involved from the beginning.	Maintenance organization not usually involved in vendor selection process.
Overall goals: Obtain product at reasonable price and as soon as possible.	Overall goal: Obtain the lowest cost product that complies with all requirements, but equal opportunity is a must.
Few review and approval steps once vendor has been selected.	Review and approval process more structured and complex once vendor selected.
Past performance weighed heavily in selection process and is often primary factor.	Past performance considered, but typically only a minor fact.
Summary:	
Commercial practices allow for more flexibility in vendor selection, while DoD vendor selection is forced by use of pre-defined metrics for proposal evaluation. The constrained process of vendor selection for the DoD is a result of their requirement to maintain the public trust. Commercial practices encourage vendors to offer best solution, despite the fact that it may not meet 100% of the requirements. In addition, under these practices, teaming and long-term relationships are more easily accommodated and are directly attributable to the success of the software development.	

Table 2.   Vendor Selection. [From: DeRiso and Ferguson]

3.   Development Process

Commercial industry and the Department of Defense share traditional approaches to the development process, however a few key differences increase the potential for success in commercial industry.   Both commercial industry and the Department of Defense have implemented reviews to monitor the level of risk associated with programs throughout all phases of software development and to ensure that adequate progress is achieved against major milestones. Yet, the key differences include the incorporation of commercial-off-the-shelf products, considerations for product architecture, the level of user involvement, and the application of prototyping.

The enhancement of existing product solutions to achieve desired user requirements is a well-known process of commercial industry. The main reason for the consistent success of this practice is their consideration for product architecture throughout the development process.   Commercial product solutions often fit into standard architectures, which enable them to take advantage of software reuse. Unfortunately, the practice of software reuse is often ignored by the Department of Defense in their software acquisition programs as a result of their desire for meeting 100% of the user requirements. As a result, the possibility that development funding is wasted by multiple efforts is high.[15] The commercial industry successfully navigates this pitfall by translating buyer requirements to more "general purpose" requirements, which fulfill the unique needs of the user, but allow for future modifications.[16] This practice is evidenced by their focused development of modules within their software product solutions. Modularity enables the commercial vendor to meet multiple user needs by compartmentalizing unique user requirements to fit within standard industry architectures. Therefore, the Department of Defense should consider utilizing standard architectures, which would enable multiple vendors to contribute to a software project,

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[15] Joab Jackson, "Report advocates open-source approach for software acquisition." <u>Government Computer News</u> (20 July 2006).

[16] Michael E. DeRiso and Jack R. Ferguson, "Software Acquisition: A Comparison of DoD and Commercial Practices." (1994).

with fewer inter-operability issues. In addition, this would also enable them to incorporate existing commercial software products into software projects to fulfill user needs, thus reducing program cost and required time to product deployment.

The difference between the levels of user involvement within commercial industry in comparison to that in Department of Defense software programs is significant. This difference can be attributed to the role the user takes on in each domain. It is standard commercial practice for the user to be heavily involved throughout all phases of software development. Generally, this is accomplished through user representation within the Integrated Product Development team. This enables the user to communicate essential input concerning the design and development of the software system. These are key aspects that users involved with Department of Defense projects rarely have the opportunity to take advantage of. With respect to Department of Defense software projects it is common practice to limit the role of the user throughout software development. User input is solicited during the drafting of requirements and during the testing phases. Therefore, it is not unusual for certain aspects of the software system's design and development to be unintentionally restrictive.

Software prototyping is the process of creating an incomplete model of the future software system with limited functionality. Prototyping allows the users to evaluate the limited features of the software system to determine requirements compliance and to generate feedback that may not have been considered during the initial design and development phases. This process has several advantages. First, the software design and development team can obtain feedback from the users early in the project. Second, the buyer and the contractor can compare if the software prototype meets the software specification. Lastly, prototyping yields insight into the accuracy of initial cost and schedule estimates and whether the proposed milestones can be successfully met. Table 3 provides a summary of common development process practices in both commercial industry and the Department of Defense.

Development Process	
Commercial Practice	DoD Practice
Vendor often tails existing systems and uses COTS. System designed to fit in a defined architecture or product line.	Varies with application. Some systems use COTS. However, usually a new system that doesn't reuse legacy software. Unique systems are built with little regard for architecture.
Buyer may have heavy involvement in design and development as part of the IPD team.	Formal, structured spiral, or waterfall model. Buyer oversees, but team approach is not typically emphasized.
Informal reviews conducted to determine progress against goals.	Very formal reviews, which include technical details in addition to progress metrics.
Heavy user involvement.	Limited user involvement, but heavy buyer involvement.
Vendor embraces one or more industry standards, which improves interface and integration with COTS products.	Limited practice of integrating industry standards with government standards due to compatibility and security issues. Additionally, COTS products do not necessarily enhance government standards.
Buyer requirements may be translated to more "general purpose" requirements for potential software reuse.	Software systems are tailored to meet user requirements with little focus on designing reusable code.
Management reviews and degree of oversight are commensurate with size and risk of program.	Notably more detailed reviews and oversight performed.
Prototyping common, with joint applications development teams working to clarify requirements and incorporate new requirements that do not affect cost or schedule.	Prototyping seldom used, but becoming more popular.
Summary:	
Commercial practices more flexible with likelihood of a team approach and is based toward reuse and modification of existing systems. Software system architecture is designed and developed with the future anticipation of product improvements.	

Table 3.   Development Process. [From: DeRiso and Ferguson]

4. Business Practice

There are many reasons for the differences in the way business is conducted in commercial industry in comparison to that of the Department of Defense. First and foremost, contracts within commercial industry are often informal, falling under the classifications of joint venture or partnership. Joint ventures and partnerships are characterized by the sharing of a program's risk, which results from vested interests and the possibility for mutual economic benefit. Department of Defense contracts are significantly more formal and rigorously structured, but most importantly they lack the inherent motivation to successfully reduce cost. This lack of motivation for the contractor to reduce cost often stems from the level of vested interest in the project. In comparison to commercial industry, in which contracts are often entered into due to the project's mutual economic benefit, the Department of Defense cannot begin to expect a reduction in program costs until they align the contractor's interests with their own.

Another major difference in business practices between these two sectors has to do with the nature of project funding. Commercial industry projects receive predictable annual funding, while Department of Defense projects often receive varying annual amounts of funding. Therefore, the unpredictability of Department of Defense funding could possibly decrease a contractor's level of motivation for reducing costs.

Lastly, there exists a difference in staffing policies that could also affect the success of the program. Commercial industry has the ability to hire\fire vendors and managers throughout the project's lifecycle. Often commercial project managers have had significant experience in overseeing multiple programs throughout their development. This expertise could play a role in decreasing the level of risk associated with commercial projects as a result of their ability to recognize situations in which cost and schedule overruns may arise. Yet, Department of Defense project managers are determined mostly by rotations of assignment, followed by qualifications, and finally training. Therefore, it is not uncommon for experienced program managers to be

replaced by less experienced individuals who are coming straight from training programs. Table 4 provides a brief summary of the differences in business practice with respect to commercial industry and the Department of Defense.

Business Practice	
Commercial Practice	DoD Practice
Informal contracting, joint ventures, partnerships with mutual economic benefit and vested interest in success.	Formal contract with little motivation to reduce cost.
Oversight built on established relationships.	Burdensome cost accounting procedures required; extensive oversight, reporting, and documentation requirements.
Ability to hire and fire vendors and managers.	Government personnel regulations, policies, and practices determine qualifications of its managers, rotations of assignment, and training.
Predictable annual funding.	Unpredictable annual funding.
Summary: Commercial practice more flexible with greater incentives.	

Table 4.   Business Practice [From: DeRiso and Ferguson]

5.   Integration, Testing, and Delivery

Commercial industry and the Department of Defense differ in the types of testing each conducts. The Department of Defense conducts both operational testing and development testing per statutory mandate, while commercial industry typically conducts only development testing.[17] A separate authority conducts the operational testing in order to achieve an impartial, independent assessment of the software system. This testing is necessary because the software system must withstand the operational environment in which it will be used, e.g. the battlefield. Since the Department of

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[17] Michael E. DeRiso and Jack R. Ferguson, "Software Acquisition: A Comparison of DoD and Commercial Practices." (1994).

Defense is required to run both development and operational tests, the software project's schedule and complexity is naturally increased. Another major difference revolves around the amount of beta testing conducted. Beta testing consists of releasing different versions of the software system to outside sources so that further testing can minimize the number of errors or bugs within the software. This practice enables the software development team to increase their product's exposure to an increased number of future users. It is common practice in the commercial sector to release multiple beta versions for testing by other users, to ensure that the final software product has few faults. However, in the Department of Defense it is much less common for a software project to go through intensive beta testing. This lack of beta testing could also be responsible for the propagation of errors throughout the software development lifecycle, thus affecting the timetable for product delivery and increasing costs resulting from software rework. It is estimated that in fiscal 2006, the Department of Defense spent as much as $12 billion, or roughly 30 percent of its estimated budget of $40 billion for research, development, testing, and evaluation, on reworking software.[18] To put this number into perspective, large commercial companies spend just a small percent of its budget on rework. Thus, it is evident that there are undeniable problems associated with the methods in which the integration, testing, and delivery of software systems are conducted in the DoD. Table 5 below compares common practices regarding integration, testing, and delivery of software systems within commercial industry and the Department of Defense.

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[18] Patience Wait, "Weapons projects misfire on software." <u>Government Computer News</u> (3 July 2006).

Integration, Testing, and Delivery	
Commercial Practice	DoD Practice
There usually exist major "cut-over" issues.	Similar "cut-over" or transition issues.
Sometimes difficult to assemble complete system in laboratory environment due to cost. Testing usually done in client's facility.	Usually integrate system in laboratory prior to operational testing. Development testing vs. operational testing required via statutory mandate.
Beta testing widely used to quickly find errors.	Minimal beta testing.
Ultimate acceptance authority rests with buyer, not a separate organization.	Structured, specified operational testing conducted by separate authority. Acceptance authority rests with buyer.
Summary:	
Integration and functional testing seem appropriate to the need. DoD use of separate test agency adds time and complexity.	

Table 5.   Integration, Testing, and Delivery. [From: DeRiso and Ferguson]

6.   Maintenance

Software maintenance has been restructured in both the commercial industry and the Department of Defense. Historically, it had been commercial practice for the buyer to support the software system.   However, it has become increasingly common to find the burden of software support being outsourced to independently contracted companies or supported internally by the vendor responsible for the software's development.[19] Commercial industry's transition from organic support to vendor-supported maintenance is motivated by cost efficiency. It costs the software buyer less to require the vendor to maintain the software it developed then it would be to actually provide the software maintenance internally.   In contrast, the Department of Defense provides software support through the use of depot maintenance as a result of their reluctance to be

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[19] Michael E. DeRiso and Jack R. Ferguson. "Software Acquisition: A Comparison of DoD and Commercial Practices." (1994).

dependent upon the vendor. "Depot maintenance is the act of repair, overhaul, upgrade or rebuild of weapons systems, support equipment, component parts, and embedded operating software programs when the level of effort required to meet specified conditions exceeds the capabilities of lower level maintenance activities (i.e. Direct Support and General Support)."[20] One of the primary reasons for depot maintenance is the increased level of responsiveness required to support software systems in the operational environment. Therefore, it is not practical to port commercial practices regarding software maintenance to the Department of Defense depot maintenance model. Table 6 provides a comparison of commercial industry and the Department of Defense maintenance practices.

Maintenance	
Commercial Practice	DoD Practice
Organic support shifting to outsourcing or vendor.	Organic support, with reluctance to be dependent on vendor. Use of depot maintenance makes interoperability issues more manageable. Must be responsive to user for critical systems.
Summary:	
The DoD and industry have different requirements and must be careful when selecting a maintenance strategy appropriate to their needs.	

Table 6. Maintenance. [From: DeRiso and Ferguson]

7. Rights in Data

The Department of Defense generally demands all rights in data since they support and maintain the software system internally. In commercial industry, there are differing practices for who acquires the rights in data. In any custom development, the buyer typically gets all rights, but it is generally agreed upon in the contract that the vendor might retain the right to subsequent sales. However, if the buyer is purchasing a

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[20] "Depot Maintenance Program Info," US Army Materiel Command, U.S. Army, 10 May 2007 http://www.amc.army.mil/G3/major_programs/dmdesc.htm.

tailored version of a standard software system, the buyer will only acquire rights to the tailored functionality, but not the standard system. This practice is common within the Department of Defense, but there exist numerous exceptions for proprietary material.

The Department of Defense has experienced many problems deriving from the practice of acquiring rights in data. Generally, the government seeks rights in data in all software projects, to prevent vendor-lockup, which prohibits the Department of Defense from awarding alternative vendors projects to improve or increase functionality, pertaining to proprietary material. Due to the inherent proprietary issues concerning software reuse, especially in legacy systems, the Department of Defense began exploring the advantages/disadvantages of open source. Within the last year the Open Technology Development (OTD) Road Map report investigated various technology development methodologies. Since OTD's inception, it has been advocating the adoption of open source standard architectures through sharing software code developed by the DoD, its affiliated contractors, and the open source community to increase the speed of the software procurement cycle. The report stated,

> Currently, within DoD acquisitions programs, software code is reused on a limited basis. For example, within an individual DoD program office, software code from a previous contractor may be shared with a new contractor taking their place.[21]

By opening up standard architectures, they can minimize the number of problems that arise as a result of proprietary material in future software programs. Table 7 contrasts commercial industry practice and the Department of Defense practice pertaining to rights in data."

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[21] Joab Jackson, "Report advocates open-source approach for software acquisition." Government Computer News (20 July 2006).

Rights in Data	
Commercial Practice	DoD Practice
If custom development, buyer gets all rights, but vendor may retain right to subsequent sales.	Specified by contract. Government usually demands all rights for government use due to organic support, maintenance needs, and competition.
If tailored version of standard system, buyer only gets rights to tailored parts.	Similar to commercial, but many exceptions for proprietary material.
Summary: Similar, but commercial is a little more flexible especially regarding resales.	

Table 7.   Rights in Data. [From: DeRiso and Ferguson]

IV. DOD VENTURE CAPITAL MODELS

The Department of Defense's ability to identify, develop, and deploy innovative commercial technologies is limited. There are commercial technologies not yet identified by the DoD as a result of their limited visibility into the newest private sector innovations. The concept of funding a portion of technology development through venture capital "exploits venture capital's efficiency in developing technology, its access to the growing commercial technology sector, its capacity to respond with agility to changing technology, and its ability to leverage additional resources throughout the development cycle."[22] The firm's required strategic focus is representative of the venture capital arms of a subset of today's most distinguished public companies. For example, both Intel and Xerox have successfully leveraged their corporate expertise and industry knowledge to expand their company's capabilities through strategic acquisitions and investments. Therefore, the Department of Defense began to explore the benefits of venture capital through a few government sponsored venture initiatives.

A. GOVERNMENT SPONSORED VENTURE INITIATIVES

There are currently a number of government sponsored venture initiatives within the Department of Defense. These initiatives span the entire spectrum of venture capital models, which ultimately seek to enable the identification and transference of technology from the commercial sector to the federal government. Government sponsored venture initiatives fall into two categories, programs that provide resources for commercial technologies showing promise in addressing specific militaristic problems and programs that serve as self-sustaining independent entities, setup to model a Venture Capital (VC) firm. The U.S. Navy Commercial Technology Transition Office (CTTO) serves as a bridge between the commercial sector and the military, matching commercial solutions

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[22] Bruce Held and Ike Chang. "Using Venture Capital to Improve Army Research and Development." Rand Corporation (2000).

with militaristic problems. However, the Central Intelligence Agency's In-Q-Tel and the U.S. Army's OnPoint Technologies are two examples of the Department of Defense's most recent forays into government venture capital models.

1.   Commercial Technology Transition Office (CTTO)

The Commercial Technology Transition Office is the U.S. Navy's program established to leverage the unique expertise of the VC community in their ability to identify viable commercial technologies. It was created in 1999 by the Assistant Secretary of the Navy to improve the successful identification and rapid transference of technology to the U.S. Navy. The CTTO is involved throughout all aspects of technology insertion, including initial assessment of the basic technology, developing program milestones, funding, schedules, testing, and finally through acceptance by the Naval buyer.[23]   Since 1999, the CTTO has successfully funded over 55 technology transition deals, each of which has been instrumental in either improving Naval capabilities or reducing total lifecycle costs for current systems.

a.   Mission

The primary mission of the Commercial Technology Transition Office is the rapid transfer of technology to improve the U.S. Navy's current capabilities. The CTTO serves as a matchmaker between Naval Acquisition Program Officers and various technology providers. In order to identify technologies that are assured to solve existing problems in the Department of Navy, the CTTO utilizes its Rapid Technology Transition Proposal Form to solicit input from Program Executive Offices (PEOs), System Commands (SYSCOMS), and Office of Naval Research (ONR) Program Managers. "Proposed technology transitions are often based on one or more factors such as program risk, schedule acceleration, improving system performance, and reducing acquisition

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[23] "Commercial Technology Transition Officer (CTTO) – Deals," Office of Naval Research, Department of the Navy, 12 May 2007 http://www.onr.navy.mil/ctto/deals.asp.

cost."[24] Sources of technology include commercial industry, academia, and government sources, both Department of Defense affiliated and non-DoD affiliated. Figure 5 below provides an overview of the CTTO deal-making process.
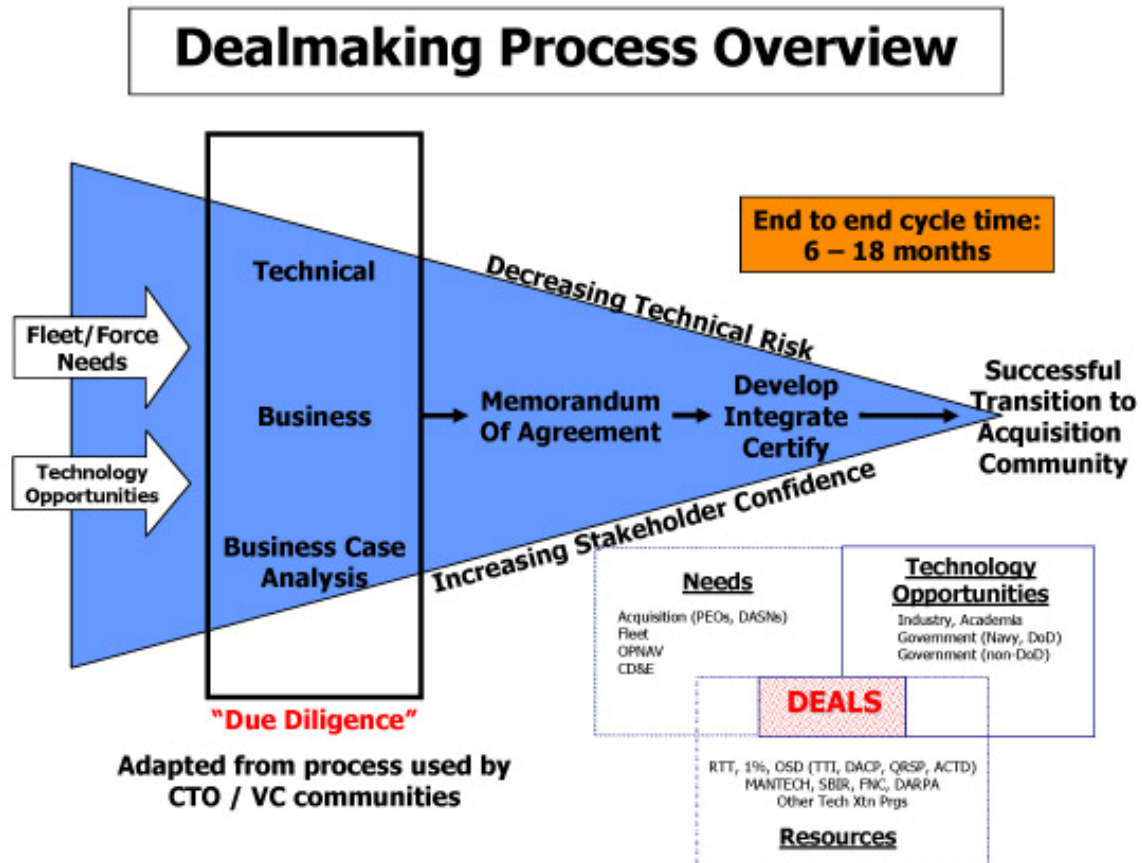

Dealmaking Process Overview

End to end cycle time: 6 – 18 months

Decreasing Technical Risk

Technical

Fleet/Force Needs

Business

Memorandum Of Agreement → Develop Integrate Certify → Successful Transition to Acquisition Community

Technology Opportunities

Business Case Analysis

Increasing Stakeholder Confidence

"Due Diligence"

Adapted from process used by CTO / VC communities

Needs
Acquisition (PEOs, DASNs)
Fleet
OPNAV
CD&E

Technology Opportunities
Industry, Academia
Government (Navy, DoD)
Government (non-DoD)

DEALS

RTT, 1%, OSD (TTI, DACP, QRSP, ACTD)
MANTECH, SBIR, FNC, DARPA
Other Tech Xtn Prgs

Resources

Figure 2.   CTTO Deal Making Process Overview. [From: Commercial Technology Transition Office]

b.   *Investment Requirements*

The difference between this program and other government sponsored initiatives lies with the CTTO's requirements for investment in technology. The threshold for technological funding is much higher within the CTTO. Additionally,

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24 "Commercial Technology Transition Officer (CTTO) – Deals," Office of Naval Research, Department of the Navy, 12 May 2007 http://www.onr.navy.mil/ctto/deals.asp.

potential technologies are evaluated on the basis of their Technology Readiness Level (TRL), which assesses the maturity of an existing technology by indicating the present status of development with respect to its lifecycle timeline. In order to minimize technology and program risks, the minimum Technology Readiness Level for investment is TRL 6, which indicates that a system prototype has been demonstrated in a relevant environment. The table below illustrates the different TRLs associated with potential technologies.

$	Roles	Steps to Transition	DoD 5000 Series Technology Readiness Level (TRL)
6.4	Acquisition Program Management	System Test, Launch and Operations System/Subsystem Development	9. Actual system "flight proven" through successful mission operations (OT&E)
			8. Actual system completed and "flight qualified" through test and demonstration (ground/flight) (DT&E)
6.3		Technology Demonstration	7. Systems prototype demonstration in a flight/space environment (System Prototype Test in Operational Environment)
			6. System/subsystem model or prototype demonstration in a relevant environment (Prototype Test in Relevant Environment)
6.2	Technology Directorate	Technology Development	5. Component and/or breadboard validation in a relevant environment (Breadboard Integration)
		Research to Prove Feasibility	4. Component and/or breadboard validation in laboratory environment (Breadboard Integration)
			3. Analytical and experiment critical function and/or characteristic proof of concept (Component Development)
6.1		Basic Technology Research	2. Technology concept and/or application formulated (Invention)
			1. Basic principle observed/reported (Paper Study)

Table 8.   Technology Readiness Levels. [From: Commercial Technology Transition Office]

Since most technologies funded by the CTTO have TRLs of 6 or 7, additional funding is often a requirement in order to yield a product that can be successfully deployed to the operational environment. Additional funding for technologies is secured through a

Memorandum of Agreement (MOA), which outlines specific actions and resources necessary to complete the technology transition. Technologies selected for transition typically receive between $500,000 and $2,000,000. This investment is significantly smaller than the average investment received for programs funded under the Department of Defense Acquisition System, which depending on the type of system can be on the order of 10's or 100's of millions. By limiting the individual program funds, the CTTO is able to reduce the amount of risk they bear with any one program. In addition, the level of control they exercise over each program directly increases the probability of successful development and transference of commercial technologies. Lastly, through its policy of investing in mature technologies that can be transitioned to enhance Naval capabilities or reduce costs, the CTTO has been able to successfully minimize risk as well as cost and schedule impacts.

2.   In-Q-Tel

In-Q-Tel is the product of the government's initial attempt at establishing a non-profit Venture Capital firm. The firm is strategically focused on the funding, identification, and transference of commercial technologies to ensure the technological superiority of the Central Intelligence Agency (CIA). The impetus for In-Q-Tel's formation was the 1998 Strategic Direction Initiative launched by the CIA's director, George Tenet. The Initiative declared that a new entity was required to speed the insertion of mature technologies and to support the rapid development of mission critical applications for the CIA and Intelligence Community (IC).[25] With the creation of In-Q-Tel the CIA had officially recognized that they could no longer rely solely on its traditional contractor base and government laboratories for cutting edge technologies.[26]

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[25] "Accelerating the Acquisition and Implementation of New Technologies for Intelligence: The Report of the Independent Panel on the Central Intelligence Agency In-Q-Tel Venture," Business Executives for National Security (2001), 16 May 2007 http://www.bens.org.

[26] Dupont, Daniel G. "The Company's Company: Venture Capitalism Becomes a New Mission for the Nation's Spymasters." Scientific American (August 2001).

a.   *Objectives and Investment Focus*

Although much of In-Q-Tel is motivated by the practices of successful VC firms, In-Q-Tel differs in its objectives and investment focus. Typical VC firms invest in technologies across various industry sectors with the goal of generating a significant return for their limited partners. Meanwhile, In-Q-Tel is solely concerned with funding the development of technologically superior products within the Information Technology sector that address its customers' needs. This includes the following four areas of focus:

- Information Security: hardening, and intrusion detection, monitoring and profiling of information use and misuse, and network and data protection.

- Use of the Internet: secure receipt of information, non-observable surfing, authentication, content verification, and hacker resistance.

- Distributed Architectures: methods to interface with custom or legacy systems, mechanisms to allow dissimilar applications to interact, automatic handling of archived data, and connectivity across a wide range of environments.

- Knowledge Generation: geospatial and multimedia data fusion or integration, and computer forensics.[27]

In-Q-Tel's success is measured by its ability to "deliver value to the Agency through successful deployment of high impact, innovative technologies, build strong portfolio companies that will continue to deliver, support, and innovate technologies for In-Q-Tel's customers, and create financial returns to fund further investments into new technologies."[28] Equity investments are the vehicle through which In-Q-Tel can participate in strategically developing commercial technologies. The typical range of investment is between $1,000,000 and $3,000,000.   In addition to tailoring commercial technologies, these equity investments are made with the goal of a future liquidity event for the portfolio company. Examples of liquidity events include acquisitions,   mergers,

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[27] Rick E. Yannuzzi, "In-Q-Tel: A New Partnership between the CIA and the Private Sector." Defense Intelligence Journal (Winter 2000).

[28] "In-Q-Tel – About Us," In-Q-Tel, 2003, Central Intelligence Agency, 12 May 2007 http://www.in-q-tel.org.

Initial Public Offering (IPO), etc. These liquidity events provide the means through which profits can be reinvested into other promising technologies, thereby creating a self-sustainable firm that is no longer dependent upon funding from the CIA.

b. In-Q-Tel Interface Center (QIC)

The In-Q-Tel Interface Center arose in response to the many concerns raised about security clearances that were often necessary to interact with the CIA. Previously, these security concerns had represented a significant hurdle, preventing the CIA from detailing its needs to outside suppliers. The QIC was formed to serve as a conduit, passing information between the CIA and In-Q-Tel and providing guidance on CIA needs and candidate technologies.[29] CIA officers armed with the expertise required to translate specific CIA and IC needs into product evaluations and descriptions staff the QIC. When In-Q-Tel makes an investment in a company, the QIC is responsible for evaluating the technology and strategically placing/developing it for use within one of the CIA's many departments or, if possible, within other government programs. According to an independent report by the Business Executives for National Security, the implementation of the QIC has been directly responsible for the success of In-Q-Tel.[30]

In-Q-Tel has been able to draw upon the unique experiences of venture capitalists, technology executives, and intelligence officers. To date, In-Q-Tel has successfully delivered more than 140 technology solutions, engaged more than 90 companies, most of which had never previously contracted with the government, and leveraged more than $1B in private sector funds.[31] These numbers are incontrovertible evidence that In-Q-Tel has proven to be a successful application of VC practices within the government.

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[29] Daniel G. Dupont, "The Company's Company: Venture Capitalism Becomes a New Mission for the Nation's Spymasters." Scientific American (August 2001).

[30] "Accelerating the Acquisition and Implementation of New Technologies for Intelligence: The Report of the Independent Panel on the Central Intelligence Agency In-Q-Tel Venture," Business Executives for National Security (2001), 16 May 2007 http://www.bens.org.

[31] "In-Q-Tel – About Us," In-Q-Tel, 2003, Central Intelligence Agency, 12 May 2007 http://www.in-q-tel.org.

3. OnPoint Technologies

Given the successful transitions of technology to the CIA and other members of the Intelligence Community via In-Q-Tel, the United States Army utilized funds to establish its own Army Venture Capital Fund, OnPoint Technologies. OnPoint was founded in 2003 as a means of strengthening collaborative ties with young, small, entrepreneurial companies that take risks and push innovation.[32] More specifically, OnPoint was created to facilitate the rapid development and insertion of promising commercial technologies to the Army.

OnPoint Technologies is a strategic investor motivated by the needs of the Army. The Army's success is directly related to the battlefield effectiveness of mobile soldiers. According to the Army, the future mobile soldier "will carry a power/energy source dense enough to operate all or most of the power/energy consuming devices needed to carry out their missions...operate for days, or even weeks, without re-supply...campaign in extreme environments and operate independently, so all of the soldier's equipment, including the power/energy sources, must be man-portable over extended distances and across extreme terrain."[33] Armed with these guidelines for what will be expected of combat soldiers in the near future, OnPoint focuses on mobile power and energy enabling technologies, such as:

- Generation – fuel cells and microturbines
- Storage – batteries and capacitors
- Management – semiconductors and software
- Controls – control circuits and voltage sensors
- Distribution – conducting polymers and superconductors
- Usage – low power logic and components[34]

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[32] "About OnPoint Technologies," OnPoint Technologies, 2003, United States Army, 18 May 2007 http://www.onpoint.us.

[33] Ibid.

[34] Ibid.

Similar to In-Q-Tel, OnPoint Technologies has modeled itself as a non-profit Venture Capital firm. OnPoint acquires stakes in companies with promising technologies through equity investments. These investments range between $500,000 and $2,000,000. Each investment is expected to yield a technology that can be tailored to enhance capabilities of soldiers in the battlefield. Though the primary criterion for investing in a portfolio company is whether the technology can be successfully transitioned to the Army, each investment is also evaluated on its potential to reach a liquidity event and thus generate a positive return on investment. Attractive companies meet both of these criteria. To date, OnPoint has made investments in seven promising power and energy technology companies, with one successful technology transition to the Army – a cutting-edge power indicator. Placing this power indicator on the BA5590A battery, the most widely used battery in the Army, is expected to save millions of dollars for the Army. Despite the fact that OnPoint is a relatively new player to the DoD Venture Capital forum, it is following in the footsteps of its parent model, In-Q-Tel. It is likely that OnPoint will attain a similar level of success with respect to its current and future investments.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. ADVANTAGES OF GOVERNMENT VENTURE CAPITAL PRACTICES

The Department of Defense continues to face numerous challenges in working cooperatively with the smaller companies that rapidly develop innovative products. From the small business' perspective, conducting business with the Department of Defense often means subjecting themselves to a multitude of regulations and security constraints they would not face in the commercial marketplace. In addition to the DoD's long and unpredictable budget cycle, there is often little or no incentive to market their products or services to the military, given it may take two to three years to potentially sell it to the DoD compared to an 18-month timeline in the commercial sector.[35] Therefore, the Department of Defense has explored venture capital models to cultivate an environment in which commercially viable technologies can be rapidly transferred to enhance warfighter capabilities.

There have been numerous advantages to the Department of Defense's adoption of the tailored VC models, In-Q-Tel and OnPoint Technologies. In-Q-Tel's strategic focus on the CIA and IC has enabled them to successfully focus its investments within the Information Technology sector. Meanwhile, OnPoint Technologies has narrowed its investment focus to the energy and power sectors to improve the mobility of the Army soldier. Through the practices of incremental funding and deal syndication, both In-Q-Tel and OnPoint are granted access to leading-edge commercial technologies, increased visibility into portfolio company operations, increased risk management, and the ability to operate outside of the bureaucratic constraints of the Department of Defense Acquisition System.

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[35] "Navy Needs to Define Path for IT Industries to Market their Wares." C4I News. (August 2005).

1.   Access to Leading-Edge Commercial Technologies

The bulk of innovation has been occurring in young commercial companies that have little experience, or visibility, with the government.[36] Equity investments between $500,000 and $3,000,000 enable the DoD VC firms to directly fund the research and development of multiple mission critical technologies at any given time.   "The conventional contractor deal might be strategic but it doesn't give you the same insight into the company or ability to influence the company as an equity role does."[37]   In addition to funding promising technologies, each is able to increase its exposure to commercial companies, thereby granting access to a largely untapped market.   Since more than 75% of the companies that In-Q-Tel works with have never done business with the government, it is evident that this approach provides an attractive alternative means for new companies to deliver technology solutions to the Department of Defense.[38]

2.   Visibility into Portfolio Company Operations

Achieving a sufficient level of visibility into contracted company operations has been a persistent challenge for almost all DoD Acquisition Programs.   Through the implementation of venture capital practices, In-Q-Tel and OnPoint have been able to increase the level of visibility they have into commercial companies. The amount of due diligence they conduct is comparable to other DoD programs. However, due to uniquely aligned interests between a candidate company and its potential investors, there is significantly less room for bureaucratic maneuvering when it comes to supplying the necessary documentation that confirms certain investment criterion have been met. Once In-Q-Tel or OnPoint have invested, it is not uncommon for their partners to be offered a seat on the company's board of directors. Acceptance of board membership grants them additional visibility into the portfolio firm's operations, directly increasing the level of

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[36] "In-Q-Tel – About Us," In-Q-Tel, 2003, Central Intelligence Agency, 12 May 2007 http://www.in-q-tel.org.

[37] Gary Arlen, "For Tech's Sake: Can In-Q-Tel's investment model translate into other agencies?" Washington Technology (22 April 2004). 20 May 2007 http://www.washingtontechnology.com.

[38] "In-Q-Tel – About Us," In-Q-Tel, 2003, Central Intelligence Agency, 12 May 2007 http://www.in-q-tel.org.

control they can exercise throughout the technology's development. Therefore, through board membership and significant due diligence In-Q-Tel and OnPoint have been able to increase their visibility into portfolio company operations, contributing to the increased number of successful technology acquisitions.

3. Risk Management

Risk management is a topic every acquisition professional is intimately familiar with, yet, still acquisition programs continue to fail throughout the DoD due to poor decision-making. Two methods of managing risk that have proved successful for the Department of Defense VC firms has been the adoption of incremental funding and deal syndication. The practice of incremental funding involves spreading out the funding of a technology over periods of time, or rounds. Funds are raised at the onset of each round, which is determined by the successful completion of pre-specified milestones. Deal syndication, a standard practice throughout the VC industry, involves generating enough interest in a portfolio firm's technology to recruit additional venture investors. As more investors contribute funds to the commercial technology, the level of risk each investor is exposed to on any one investment is correspondingly reduced. Since In-Q-Tel and OnPoint syndicate all investments, their total exposure to any individual portfolio company is limited through this practice of risk diversification. Another advantage to syndicating deals is the opportunity it presents to leverage the capital of additional investors, allowing In-Q-Tel and OnPoint to invest in other promising technologies.

As mentioned previously in this paper, the Department of Defense Acquisition System has not been able to keep pace with the development of technology in commercial industry. The bureaucratic constraints of traditional acquisition programs have been responsible for unpredictable annual funding and poor risk management, both of which result in cost and schedule overruns that directly impede the transition of technologies from concept to deployment. Simply put, companies that are not part of the traditional contractor base don't want the headaches associated with government

accounting and acquisition regulations.[39] The formation of Venture Capital models has provided a successful vehicle for accessing the entrepreneurial community, which is at the forefront of developing today's innovative technologies. In-Q-Tel and OnPoint Technologies have proven to be capable methods of rapidly identifying, acquiring, and transferring commercial technologies, while minimizing risks and maximizing the number of successful acquisitions. However, the incorporation of a full-fledged VC model to improve DoD software acquisitions is unnecessary. Certain characteristics of an acquisition project lend itself to the incorporation of venture capital practices. The development of technology by a young company or startup, increases the overall level of risk associated with the program. In addition to technology risk, there is the introduction of company risk, the risk of bankruptcy, merger, or acquisition, which could delay or even prevent the technology's development. In addition to elevated risk, if the technology developed met the needs of several DoD-affiliated organizations, it would be an ideal candidate for the implementation of venture capital practices. The implementation of venture capital practices should be used to complement the conventional acquisition process, rather than replace it. Therefore, incremental funding and deal syndication should be applied to improve the number of successful software acquisitions.

B.   RECOMMENDATIONS

The most common reasons for why software acquisitions typically fail have been identified throughout this paper. The Department of Defense Acquisition System is a long and tedious process, filled with numerous regulations and restrictions, which serve to manage the risks associated with procuring technology. However, year-after-year this Acquisition System has resulted in a significant number of software acquisition failures. There are many current practices that can be improved or modified based on the analysis of comparable commercial practices and the advantages of venture capital investment and

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[39] Daniel G. Dupont, "The Company's Company: Venture Capitalism Becomes a New Mission for the Nation's Spymasters." Scientific American (August 2001).

management practices, many of which have been discussed in this chapter. The following are a few additional recommendations that should be considered to improve the regulations governing the acquisition of software systems.

- More aggressive metrics for vendor selection to measure both current ability to perform and past performance. It is necessary to improve the level of visibility the Department of Defense has into contracted companies; often it is too late before issues are recognized, addressed, and resolved.

- Encourage collaboration among competing vendors on large complex software systems. This practice would reduce the overall risk of each party involved, by enabling the DoD to award smaller amounts of capital to each vendor, thereby forcing them to utilize their individual resources efficiently and resulting in improved cost management practices.

- Push for the incorporation of open source standards into software systems to maximize the amount of software reuse within the DoD. Software reuse will minimize the cost of procuring future software systems, while also reducing some of the risks associated with software development.

- Software architectures should be open, allowing for the incorporation of rapid changes and providing the ability for multiple vendors to contribute through the development of critical components and/or customized modules for software systems. Through the use of modules, the set of requirements can be broken down into subsets of user requirements or individual components designed to complete specific tasks. Modules increase the level of customization that can be achieved for each user, by allowing the same software system to satisfy the needs of multiple users. The goal should be to build smaller, simpler, cleaner software components that can easily be incorporated into existing open software architectures.

- Facilitate iterative software development through either incremental or evolutionary models. These models are particularly advantageous since they yield a working product at the end of each iteration. Thus, in any instance where additional funds cannot be appropriated or cost and schedule overruns lead to program termination, the program will have successfully yielded a working prototype that could be further developed by another program office or incorporated into an existing system. These models incorporate the newest technology in each successive prototype. Additionally, software requirements are continuously improved and aligned with user needs. Iterative software development is ideal for medium to high-risk projects, where requirements are expected to evolve due to a large number of diverse users each with their own set of needs.

- Function points should be the primary method for determining software development cost. The function point method focuses on five different

factors that relate to user requirements: inputs, outputs, logic files, inquiries, and interfaces. Under this method, a secondary system tracks the number of times each one of the function points is executed in the software under development and then total cost is calculated by multiplying the number of times each function point is performed by its respective cost. Thus, the software system's size is based on user-defined functionality and not the number of lines of code required to complete the task.

- Relaxation and/or modification of rotation assignments for DoD software acquisition professionals. Program managers should be required to stay with programs throughout initial testing to maintain continuity and understanding of original requirement nuances. Their unique understanding of the software development is crucial to the program's success.

- Syndication of projects across various program offices and services of the DoD. Deal syndication has proven extremely successful throughout the VC industry in increasing the successful development of commercial technologies. By seeking out interested parties, program risk and funding can be split amongst the group, thereby reducing any one program office's or service's exposure to program risk. Therefore, if any one of the invested parties cannot appropriate its portion of the program's funds, the chances of project termination are reduced.

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